

## Coastal and Continental Shelf Processes in Ghana

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### LONG-TERM GOALS

The long-term goal is development of the competence of local researchers to carry out scientific investigations into various facets of coastal processes in Ghana through the establishment of a sustainable program at the University of Ghana. The program also seeks to support research in maritime domain awareness through processing of a suite of remotely sensed imageries for maritime surveillance and environmental vulnerability assessment.

### OBJECTIVES

1. To carry out a wide range of *in situ* measurements in the nearshore zone to facilitate investigation into shoreline change in Ghana
2. To develop capability in analyses of Synthetic Aperture Radar (SAR) imageries to complement research in coastal processes, including detection and analysis of oil spills and maritime traffic in the Gulf of Guinea
3. To investigate the upwelling dynamics in the Gulf of Guinea with the purpose of developing a model to simulate this phenomenon. Performance of existing coupled atmospheric-ocean models with meso-scale resolution would be assimilated with data for forecasting.

### APPROACH

Ghana's coastline measures about 550 km and is generally a low-lying area below the 30 m contour. It has a continental shelf extending outwards to between 25 and 35 km except off the western coastal area where it reaches up to about 90 km. Waves approach the open coast of Ghana from the south-southwest direction. The significant wave height at 50% of the time is about 1.4 m and the period is from 10 to 15 seconds (Apeaning *et al.*, 2008).

The coastline is experiencing relatively high rates of erosion and has affected the social and economic life of coastal communities; threatened cultural heritage sites (i.e. Forts and Castles), collapsed industries and threatened coastal habitats. The ongoing ONR-supported coastal processes research in the country is the first comprehensive research program of the coastline, using state of the art equipment.

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A framework for monitoring the coastline has already been established through collaboration with scientists from the United States and Europe (i.e. University of New Hampshire, United States Geological Survey, Woods Hole Oceanographic Institution, and UNESCO-IHE of Netherlands). The research program is being carried out at different spatial scales – (1) large scale coastline development of order 100 - 1000 km, (2) large scale shelf processes of order 100 - 1000 km, (3) large scale nearshore processes of order 10 - 100 km, and (4) medium scale coastal inlets and adjacent beaches of order 1 - 10 km.



*Figure 1. Rapidly eroding beach (real time kinematic survey using differential GPS)*

## **WORK COMPLETED**

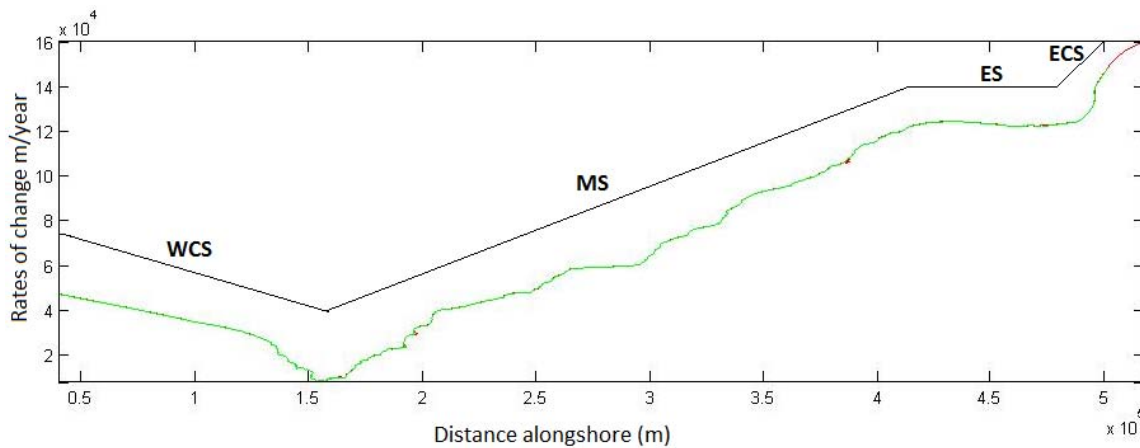
Field techniques involved the use of differential GPS for real time kinematic (RTK) survey of the shoreline. The dGPS was mounted on an ATV or a mono-cycle depending on the terrain (Figure 1). Cross-shore beach profiles were carried out within the inter-tidal zone as well as of any cliffs and dunes in the vicinity. As part of implementing this research, ground control points were established along the entire coastline of Ghana to aid with the GPS surveys.

Data gathered so far provides a baseline for comparison with historical and future coastline change. Part of the year's activity included strenuous effort to acquire historical orthophoto maps of the coastline of Ghana in an attempt to determine longer-term shoreline change for the entire country. Digitized shoreline position of 1974 and 2005 were obtained from the Survey Department of Ghana. The reliability of the 1974 shoreline was determined by estimating the positional accuracy against identifiable permanent features on the 2005 orthophoto map. This was necessary since the 1974 shoreline was extracted from digital topographic map generated from near vertical aerial photographs using the analogue photogrammetric methods.

The End Point Rate (EPR) method was adopted to estimate historic rates of change for Ghana. A baseline established landward of the coastline enabled orthogonal transects to be generated at a

predefined intervals (i.e. 200 m), crossing the two shoreline positions along the coast. The method calculates the rate of change by dividing the distance of shoreline movement by the time elapsed between the earliest and the latest measurement using the Digital Shoreline Analysis System (Thieler *et al.*, 2005). This method was selected because it requires only two shoreline positions to obtain a rate of change, as is the case in this study. The method is also considered as the most commonly used method to compute shoreline rate of change (Crowell *et al.*, 2005; Genz *et al.*, 2007). However, the approach has inherent sources of uncertainty which might affect the reliability of computed rate of change (Genz *et al.*, 2007). Changes in magnitude of the shoreline movement trend may be missed due to the likelihood of omitting important trends as the temporal variation increases. The level of uncertainty was quantified in order to determine the level of confidence in the rates calculated.

For the purposes of data analyses, the shoreline was classified into four zones based on its orientation (Figure 2). This is in contrast with previous demarcation into eastern, central and western zones, based on the geomorphology (e.g. Ly, 1980). Apart from the eastern coast that has dominant sandy beaches, the western and the central coast have both sandy and rocky beaches, making such classification redundant.



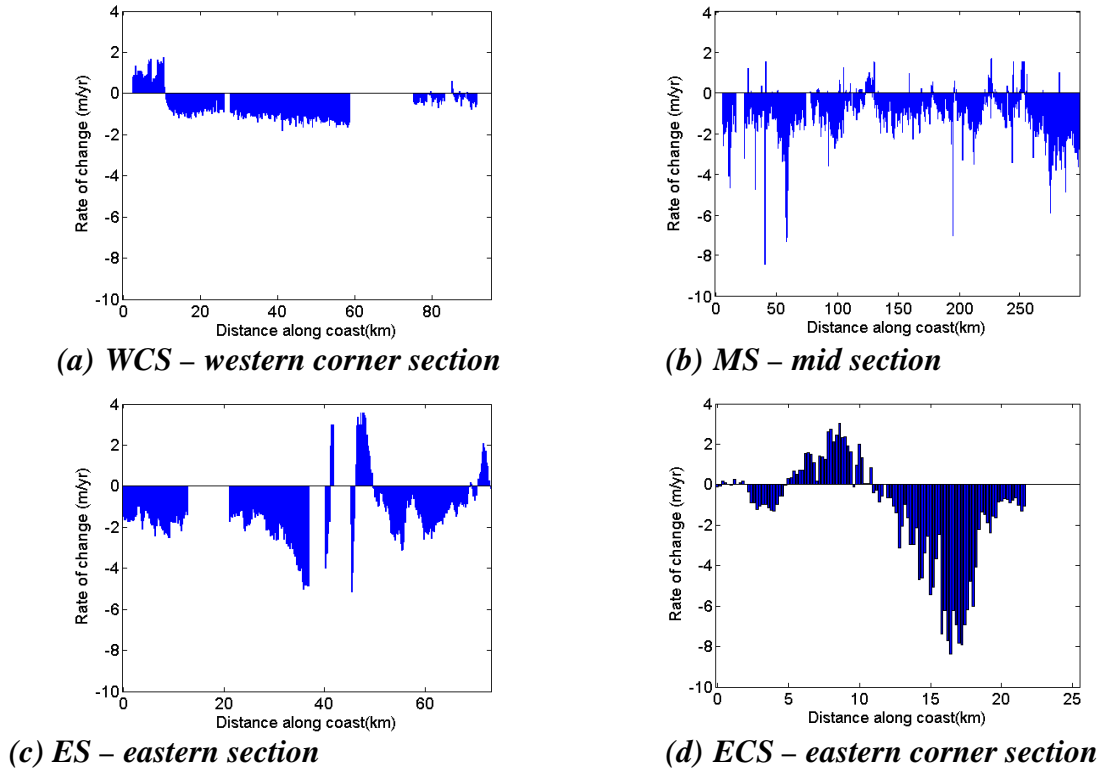
**Figure 2. Classification of the coastline of Ghana based on orientation (WCS – western corner section; MS – mid section); ES – eastern section (ES); and ECS – eastern corner section).**

The varying shoreline orientation influences how breaking swell waves and ‘seas’ interact at the various sections of the coast to drive shoreline change. Hence, the classification adopted in this study. The shoreline orientation also regulates alongshore sediment transport, which is reported to move from west to east (Wellens-Mensah *et al.*, 2002).

## RESULTS

The results indicate that the four classified sections of the coastline are experiencing different levels of change. Analysis of the 1974 and 2005 shoreline positions showed that rate of erosion towards the far eastern sections (i.e. ES and ECS) measures 1.28 m/yr, compared to 0.35 m/yr and 0.92 m/yr for WCS and MS, respectively. The level of uncertainty was quantified as  $\pm 0.22$  m/yr, and although considered high, is appreciable, based on the relatively short temporal term of the data used (i.e. 31 years).

Detailed analysis showed accretion at certain portions of the shoreline, especially at the western end of WCS (Figure 3). This observation could be due to alongshore current depositing considerable amount of sediment from the Aby Lagoon located at the Ghana–Côte d’Ivoire border. The results from the MS sections compares with Appeaning Addo *et al.*, (2008), who carried out an intensive study of Accra using data spanning 98 years.



**Figure 3: Pattern of shoreline change at the four sections (see Figure 2).**

The ES and the ECS are experiencing more erosion than accretion (see Figure 3). Following the construction of the Akosombo Dam, upstream of the Volta River, the amount of sediment discharge has reduced considerably (Wellens-Mensah *et al.*, 2002), and thus could contribute to the observed rate of erosion, especially in this sector. Hence, it provides an opportunity to carry out investigation into sediment budget as part of the effort to understand ongoing changes along the coastline.

## IMPACT/APPLICATIONS

The study for the first time has estimated the rate of coastal erosion along the entire coast of Ghana. This information is significant for developing pragmatic coastal environment policies for sustainably management of the coastal area. Through a collaborative effort with our external partners, novel investigative approaches in coastal processes research are being developed. Through workshops and hands-on training for local scientists and scientists from neighboring countries, such expertise is also being translated across the region so as to ensure standardization in data gathering and adoption of best practices.

## RELATED PROJECTS

- (a) Shoreline management workshop on ‘Forging institutional collaboration towards effective shoreline management for Ghana’

One day stakeholders’ workshop was organized for practitioners, decision makers, and international partners to exchange ideas towards development of an integrated shoreline management strategy for Ghana. The workshop was necessitated by the fact that several activities taking place in the coastal and marine environment are to a large extent uncoordinated and oftentimes, duplicative in nature. In many cases, results from completed projects are unavailable to relevant institutions/bodies to implement laudable recommendations and translate them into appropriate policies.

In line with the context of the theme for the workshop, issues that were addressed include problems associated with *ad hoc* approach to shoreline protection, impacts of rising sea level on Ghana’s coast, concept of integration of management interventions with wider natural processes and long term monitoring, and the importance of collaboration among practioners/institutions in order to ensure optimal use of resources and manpower.

The workshop achieved four main goals: i) promotion of innovative thinking to forge effective collaboration among stakeholders; ii) initiated dialogue towards crafting a strategic framework for development of a shoreline management plan for Ghana, and iii) re-enforced ongoing efforts to develop strategies for overall maritime domain awareness; iv) development of a mechanism for data/information sharing.

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